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Energy Outlook: Coal To Reign Supreme Beyond Year 2000

40130070 Beijing JINGJI GUANLI in Chinese No 2, 1988 pp 26-31

[Article by Liu Jingtong [0491 2529 1749]: "China's Energy Resources and the Development of the National Economy"--edited by Liu Qichang [0491 0366 2490]]

[Excerpts] Energy is still a major restricting factor in the development of our national economy, but economic development is not only determined by energy resources. The development of China's energy resources should have its own characteristics--we cannot just copy models provided by other countries in resolving their energy problems. At the present stage, where energy supply and investment are both insufficient, the problem of how we are to develop energy resources and economize on energy so as to satisfy the needs of economic development is one which we are hard-pressed to find a ready-made solution for in the experiences of other countries. We can only progress by proceeding from China's actual situation, adopting correct countermeasures and exploring our own road. This article will give some ideas on various important questions in the exploitation of our country's energy resources.

Present Energy Situation in China

The present energy situation in China is one of rich resources and rapid production development but where the contradiction between supply and demand remains acute.

In 1986, the verified reserves of coal were 845.86 billion tons. On the basis of the present scale of exploitation and the situation in terms of recovery of resources, these reserves can be exploited for over 300 years. The prospects for oil reserves are also very good. In a situation where world oil resources are diminishing and many researchers abroad believe that current resources can, on average, only be exploited for a few more decades, China's oil exploitation both on-shore and off-shore is only just beginning. The potential hydroelectric resources are approximately equivalent to a figure in excess of 300 million kilowatts, and a large proportion of this has not been exploited. There are also very good prospects for other energy resources, such as natural gas, nuclear energy, solar energy, wind energy as well as methane gas in the rural areas. Seen from the long term, with resources as rich as these, it will be entirely possible to satisfy our economic development needs.

Since 1980, there has been great development in our energy production. During the period of the Sixth 5-Year Plan from 1981 to 1985, there was an annual growth in coal output of 50 million tons, an average annual growth rate of 5 percent. In 1986, the output of raw coal totaled 894 million tons. The situation whereby the output of crude oil hovered around the 100-million-ton mark has also been changed in recent years and in 1986, the output reached 130.6 million tons. In 1983 there were new developments in oil prospecting work and the speed of growth in reserves began to exceed the speed of growth in output volume. This has provided reliable resource conditions for increasing crude oil output. The average annual growth of electricity generation is over 5 percent and in 1985 the power generated reached 410.7 billion kilowatt-hours (of which hydroelectricity constituted 92.4 billion kilowatt-hours), ranking China fifth in the world in terms of generated electricity. In 1986, the output was 449.5 billion kilowatt-hours. In 1985, the output of natural gas was 12.93 billion cubic meters and in 1986, this figure reached 13.76 billion cubic meters. There have also been great achievements realized in saving energy. The amount of energy consumed per 10,000 yuan of national income dropped from the 1981 figure of 15.36 tons of standard coal to 13.14 tons in 1985. Due to the dual policy implemented in the energy field of both increasing production and economizing on energy consumption, the demands of industry and agriculture during the Sixth 5-Year Plan, when average annual growth reached 11 percent, were basically satisfied.

Today's major energy problems involve: 1) There is still a great disparity between energy supply and demand. While the tight coal supply has been temporarily alleviated, electricity remains in short supply, especially in the industrial belts along the coast, in the northeast and in the central-south. 2) A new growth tendency has appeared in energy consumption. In the short term, the development of high energy consumption industries such as those involving raw and semifinished materials may speed up and there will be rapid development of household electric appliances and rapid development of tertiary industry. These situations will result in the contradiction between energy supply and demand intensifying. 3) Basic transportation and communications facilities are unable to satisfy demands in terms of transporting large volumes of energy resources from the production sites of the points of consumption. 4) Energy use efficiency is low and consumption per unit of output value is too high. The task of achieving energy savings through readjustment of the industrial structure, improving enterprise management, and speeding industrial and technological transformation remains very arduous. 5) The growth of coal exploitation and the increase in the volume of fuel coal has meant that the tasks of controlling environmental pollution and improving the ecosystem have become quite heavy.

Thus, in the present situation where state funds are insufficient and there is a rapid increase in energy consumption, we need to resolve a series of related problems through energy policies, and the organization and planning of energy exploitation.

Energy Policy Whose Main Component Is Coal

In China's energy production and supply, coal has all along occupied the leading position. In the energy production and consumption structure of the 1950's, coal constituted over 90 percent. In the 1960's and 1970's, following the exploitation of oil, natural gas, and hydroelectricity, the percentage constituted by coal declined, and in the last few years, the percentage has remained at 70-plus percent (see table).

Table. Total Energy Consumption and Its Structure

Year	Total domestic energy consumption (million tons standard)	Percentage of total energy consumption: Coal	Oil	Natural gas	Hydro-power
1953	54.11	94.33	3.81	0.02	1.84
1957	96.44	92.32	4.59	0.08	3.01
1965	189.01	86.45	10.27	0.63	2.65
1978	571.44	70.67	22.73	3.20	3.40
1980	602.75	72.15	20.76	3.10	3.99
1981	594.47	72.74	19.96	2.79	4.51
1985	770.20	75.92	17.02	2.23	4.83
1986	808.82	76.03	17.06	2.26	4.65

Seen from China's actual conditions, the situation wherein the energy production and consumption structure coal constitutes 60 to 70 percent is unlikely to see any major change before the end of the century. Also, even in the early part of the next century it is not very likely that the situation where coal constitutes the major part of energy consumption will see any change. This is because:

1. Of China's energy resources, coal reserves are not only rich, but exploitation is quite easy. Further, geological prospecting is quite practicable, and this provides the conditions which make large-scale exploitation possible.

2. The coal industry already has a rational base. Apart from state unified distribution coal mines which are of a quite large scale and fairly highly mechanized, the locality-, township- and individually-run coal mines are also developing quickly.

3. The energy resource needed at the present stage by most of the production technology and equipment in the various industries and trades in China, and by people in their daily lives, is coal. Changing the energy structure in which coal is the major fuel cannot be done at the present stage. Apart from energy resource conditions, the various industries and trades are also subject to various constraints such as investment, production costs, and pricing.

4. In terms of the world energy development situation, oil resources are gradually declining and many industrially developed countries are, after the two oil crises, economizing on oil consumption, exploring new energies, and increasing the exploitation and use of coal. We cannot, just because of the good prospects in oil exploration and production, slacken in the exploitation of coal and take the old road taken by others.

Arrangement of Coal Exploitation

In the arrangement of coal exploitation, there is the problem of how to arrange the relationships between the north and the south and between the east and west. Because China's coal resources are mainly concentrated in the northern and western regions, while coal is mainly consumed in the northeast, the eastern coastal region and the central-south where industry is fairly centralized, a situation has arisen whereby "northern coal is transported south," "western coal is transported east," and "coal has to go through the passes."

For a time in the 1960's and 1970's, opening up coal mines close to areas where large volumes of coal were consumed to change the situation whereby "northern coal is transported south" was considered. A large number of personnel, and large quantities of material and funds were assembled and sent to several southern provinces to look for coal and construct mines. The result was that not only was the situation of "northern coal being transported south" not changed, but the exploitation of northern coal fields and the construction of transport facilities in the north was relaxed. This, it must be said, is one of the major reasons why energy is in short supply today.

In terms of the east-west arrangement, it will be necessary to appropriately strengthen the exploitation of coal in the eastern region and reduce the pressure which exists due to the great distance over which the coal has to be transported, at least until the end of this century. In Heilongjiang, Anhui, and Shandong provinces there are also some coal resources which we can continue to exploit and utilize. However, the verified reserves of coal in the eastern region are limited and the investment per ton necessary for deep-level extraction of coal is also high. But regardless of whether we speak in the short term or the long term, the coal which can be exploited in this region will be insufficient to satisfy their greatly increasing energy needs. It is estimated that at the end of the century, the amount of coal brought into this region from outside will represent an increase of over two times compared to the figure at present. Thus in planning coal exploitation and shipping between the eastern and the western regions, we should appropriately utilize the eastern region and place the focus of development on the central and western regions.

Many years of practice have proven that in the arrangement of coal exploitation not only must we recognize the objective reality of "having to transport northern coal south," but that we must also recognize the inevitability of "having to transport western coal east" and "having coal go through the passes." It will be very difficult to change this situation by the end of this century or even in the early part of the next century. This is also the basis on which we have to organize the coal industry and transport and communications construction. Of course, this situation does not mean that we can unrestrictedly increase the long-distance transport of coal and mineral products from the western regions to the east. It is worth noting that in a situation where the coal resources in the eastern region are gradually declining, if the eastern region industrial structure is not firmly readjusted, it continues to proceed on the basis of immediate benefits, it continues to develop industries which consume great amounts of energy, and there is not active development of the high energy consumption industries in the central region where energy resources and mineral resources are rich, then no matter how communications and transport are strengthened, there will be no way to satisfy the energy demands of the eastern region. We should pay attention to avoiding such an eventuality.

At the beginning of 1983, the State Council decided to establish an energy base centered on Shanxi. In 1984, the scope of the base was again extended to include Shanxi Province, Shaanxi Province north of Qinling, the Inner Mongolian Autonomous Region excluding the three eastern meng, the western part of Henan, and the Ningxia Autonomous Region. Also, the State Council especially established the Shanxi Energy Base Planning Office to plan and coordinate this base. This was an attempt at breaking down the divisions between departments and regions in order to carry out economic structural reform. This base occupies 12.2 percent of the territory of the whole country, while the population of the area constitutes 9.6 percent of the national total. The coal reserves within the base are great, the range of coal types complete, and the quality of the coal is good. The deposits are close to the surface, exploitation is easy, and verified deposits constitute over 70 percent of the national total. At present, this base provides 88 percent of the total national commodity coal sent to other provinces, and by 1990 this figure will rise to 90 percent. It is the nation's biggest commodity coal base.

In general, the areas throughout the country which have coal, such as the northeast, the coal regions, the southwest and Xinjiang, can carry out exploitation in accordance with their own conditions. However, the speed and scale of the development of this base will directly affect the progress of China's modernization.

Principles of Coal Exploitation

In order to economize on investment and speed the exploitation of coal, in the construction of coal mines the policy of combining the large, the medium-size, and the small and taking the medium-size and small mines as the major component should be adopted. However, stressing that medium-size and small mines should constitute the main part does not mean that we should not build new large-scale coal mines. At the end of this century, we will, in accordance with the financial and material abilities of the state, selectively build some more large-scale pits and open-cut coal mines.

The reasons we are, in the short term, stressing the development of medium-size and small coal mines, and especially going all out to develop township and small town coal mines, are mainly: 1) Our economic strengths do not allow us to build many large, modern mines to satisfy the pressing energy demands of the national economy. Thus, the development of medium-size and small coal mines is determined by the subjective and objective conditions at the present stage. 2) The development of medium-size and small coal mines will enable the rich coal resources and the surplus labor in the rural areas to be linked up. In areas where the coal resources are rich, the exploitation conditions good, the transport quite convenient and there is quite a lot of rural labor, we should support collectively- and individually-run mines. People in areas where there is no coal can also go to areas where there is coal to start mines, so that the resource superiority can be turned into economic advantage as quickly as possible. 3) Developing medium-size and small coal mines, especially township and small town coal mines, means that the coal that will be obtained will not be far below the surface. The investment per ton of coal for such operations is only about one-third that needed for pit mines. 4) By greatly developing medium-size and small coal mines, not only will the state get coal and increased tax revenue, but it will also be beneficial to the prefectures and counties and can speed the pace at which the peasants become prosperous.

Of course, in going all out in developing township and small town coal mines, there is a need to engage in work in a down-to-earth way. We cannot "rush headlong into mass action," let things drift along by themselves or harm the resources. At present, the problems which require resolution are: 1) We must clearly set down a policy which encourages and supports coal mine development by townships and villages, and which will not be changed for quite a long period. This will allow the peasants to be free of worries and they will have the enthusiasm to expand reproduction. 2) We should designate exploitation areas, so that the resources are fully and rationally used, and so that the unified distribution coal mines, the local coal mines, and the township and small town coal mines all have their place. 3) We should encourage coal mines to increase their self accumulation capabilities, and sort out the various irrational changes which are levied on coal mines. We must increase the proportion of after-tax profits retained by the coal mines, increase fees payable to coal pits per ton of coal, and have this used exclusively for technical transformation. It will also be necessary to stipulate management and transport fee standards to be received by coal transport and marketing units. 4) The funds for developing township and small town coal mines should mainly be self-raised and the state can give support through providing preferential conditions in the areas of credit, tax, and pricing. Even better preferential conditions should be provided to old base areas, minority areas, and border areas. 5) In the fields of materials supply, training of personnel, and management systems, we should, in accordance with the spirit of economic structural reforms, make appropriate stipulations.

Today, the shortage of energy in China is mainly manifested in the insufficient supply of electricity. Thus, it is necessary to focus on electric power in energy construction.

In energy construction, hydroelectricity, thermal electricity, and nuclear power must all be developed. However, the construction of large-scale hydroelectric stations requires a large initial investment, the construction period is quite long and the power generation is subject to the restrictions of seasonal water volume. Only when they are appropriate combined with thermal power stations can good economic benefits be obtained. Also, 75 percent of China's usable hydroelectric resources are centralized in the southwest, far from the eastern coastal regions which use a large volume of electricity, and which need to be developed following the development of the overall economy. Seen from the present situation it is more realistic to first develop some small- and medium-scale hydroelectric power stations. In those areas where there are rich resources for running small hydroelectric power stations, and which lack other energy resources, and there are over 1,000 such counties, we should particularly develop small-scale hydroelectric power stations.

As to nuclear power, this has just begun in China. Because the investment required is great, in the near term this area is unlikely to see greater development. According to a report in August 1984 by the International Atomic Energy Agency, of the world's present electricity production, nuclear-generated electricity only comprises about 12 percent.

Thus, on the basis of our energy resources structure and the development of the coal industry, until the end of this century, we should mainly be building thermal power stations. In this way, investment will be relatively less and the construction periods will be shorter. This will be very important in alleviating the situation at present where electricity is in short supply in China. In the construction of thermal power plants, we should not stress uniformity. We can build power stations in regions which are near coal and water resources and we can also build some power plants in areas which at present use large volumes of electricity and which have the conditions, and then transport coal to fuel them. However, the construction of power plants must be combined with the overall industrial layout and the readjustment of the industrial structure in the various areas.

In the same way, construction of power stations is subject to the restrictions of investment, equipment, and construction periods. For a certain time to come, the speed of industrial development will have to be in accord with the rate of growth of generated electricity. An excessively high industrial growth will not only result in electricity being unable to maintain a lead, but will cause it to lag behind. Thus, in the future we must, in accordance with the feasibility of energy growth, and in particular, growth in electric power, control the speed of industrial development at an appropriate level.

Energy Conservation

The concurrent development of energy resources and economizing on energy consumption are two important aspects in the resolution of China's energy problem, and neither should be overemphasized at the expense of the other. Doing as much as possible to develop energy resources and doing as much as possible to economize on energy consumption is the energy development strategy for achieving the economic development goals for the end of this century. In the past we also stressed economizing on energy, but the results were very limited. On the one hand this was due to industrial production technology and technical equipment being backward, energy use efficiency being low (calculated on the basis of comparable energy consumption, the amount of energy consumed by China's industrial enterprises is about one-third higher than the figure for industrial countries, while if calculated per 10,000 yuan of output value, the differential is even greater) and technical transformation often being aimed solely at seeking quantity and output value. On the other hand, this was due to the "big pot" system in distribution of energy quotas and the low price of energy. This gave rise to excessive demand by enterprises and they only concerned themselves with vying for energy from the state rather than paying attention to use efficiency. This gave rise to much waste.

This also shows that the potential for saving energy in our country is very great. Over the last few years, the state has adopted a series of administrative and economic measures and there has been great advances in saving energy. For example, after the state implemented an energy saving contract with Anshan Iron and Steel Works, the total volume of energy consumption did not rise in 1984, while the profits realized were 15.65 percent higher than in 1983. Apart from readjusting the industrial structure, again appraising and deciding on enterprises' energy consumption, implementing energy saving rewards and other administrative and economic measures, reliance on technological progress to save energy should be placed in an important position. At present, the technological transformation of old enterprises should take the improvement of product quality, the increasing of types and varieties, the improvement of the environment, the reduction of the consumption of raw and semifinished materials, and especially the reduction of energy consumption as important targets.

Numerous Channels for Resolving the Problem of Funds for Developing Energy Resources

The development of energy resources requires large investment. Facts have proven that if we do things by the traditional method and completely rely on state investment, it will be very difficult to resolve the energy supply/demand contradiction in the short term.

In the short term, the method of having peasants run small coal mines and having users pool funds to start power stations can fully motivate the enthusiasm of the various sides for engaging in energy development. However, this is not to say that investment for opening coal mines and building power stations absolutely must be differentiated according to the above-mentioned sources. Following the development of the economy, state support may increase, but we cannot return to the old road where the state alone engages in energy resource development.

Collecting construction funds must indeed break down the traditional "closed-door" type economic practices. Under the guidance of the policy whereby the whole country is being opened to the outside, all areas should pay attention to doing well in the two "opening ups." That is, they should open themselves up to the outside world and open themselves up to other provinces, regions, and cities, so as to develop lateral economic alliances to promote the lateral flow of funds. For example, the provinces and cities of the coastal areas which lack energy resources and raw materials can go to the energy bases and start mines and run factories. Then, the products and profits of the operations can be divided in accordance with the size of their respective investments. In the same way, the energy base areas can use their own energy resources, primary products and other raw and semifinished materials to purchase shareholdings or an investment in the coastal regions. Thereby they will be able to use the relatively high economic benefits of the coastal regions to accumulate funds as quickly as possible for the development of the energy bases.

The accumulation of construction funds involves the reform of the current energy prices. At present the prices of our country's energy are too low, and in particular the price of coal needs to be readjusted. There should be a rational price parity between the energy prices in different areas. For example, the price of the coal and electricity consumed by the energy bases themselves should be lower than the price outside the bases. Only thus will they be able to attract other provinces and cities to come to the base area to run mines, to run raw and semifinished materials industries, and run high energy consumption industries. In the development of energy resources and the development of the economy we should mainly rely on our own funds. However, cooperation from abroad is also necessary. At present, some countries are paying attention to China's energy resource development and have begun to make investment in China and engage in technological and economic cooperation. However, seen overall, the progress has not been great, and foreign businesses still have many worries. Various foreign economists and foreign companies are paying attention to China's great market and some companies want to get their own share of this market. However, the majority have short-term goals and only a few have long-term goals. Some only want to sell technology and others only want to sell equipment in order to get profits as quickly as possible. Seen from the two sides' long-term interests, this is not enough. At present, China does not have sufficient funds or foreign exchange and there cannot be much business if China just imports. It is necessary for there to be both imports and exports as only thus will China have the capacity to pay. If business is to be expanded, there must be mutual assistance by the two sides. Foreign companies have long been engaged in cooperation with our country. If foreign governments and international financial organizations would provide medium- and low-interest loans over long periods, this would promote the construction of China's basic energy and communications facilities, and would also open wider fields for their own investment and products.

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New Energy Minister Discusses Organization, Problems

40130074 Beijing ZHONGGUO XINWEN SHE in Chinese 0840 GMT 27 Apr 88

[Article by Wei Lin [7279 2651]]

[Excerpts] Beijing, 27 Apr (ZHONGGUO XINWEN SHE)--A few days ago, Huang Yicheng, newly appointed minister of energy, was interviewed by a ZHONGGUO XINWEN SHE reporter on how to organize the Ministry of Energy and on domestic energy problems.

Plan for Organization Approved by State Council; Size Temporary Fixed at 450 People

He said that it is most difficult to organize the Ministry of Energy because of the large number of departments merged into it. These departments include those of the oil, coal, power, and nuclear industries. All these major systems fall under the category of energy, but as far as production and technology are concerned, they do not share many similarities. The plan for the current organization of the Ministry of energy has been repeatedly discussed and revisions have been made on nine occasions. It has now been approved by the State Council. The Ministry of Energy will have 18 departments under it and its complement of cadres is temporarily fixed at 450. Efforts are being made to start operation of the ministry in 3 months.

Several Steps Will Be Taken To Harmonize Relations

Speaking about specific arrangements for the four major systems, he said that it is necessary to harmonize relations and that this cannot be done in one go. Several steps have been planned. First, in the electric power system, power networks have been formed in east, north, central, northeast, and northwest China. Several companies can be set up in various regions this year and next. In the coal system, two companies will first be set up, the Northeast Inner Mongolia Coal General Company in the north and the China Unified Distribution Coal General Company south of the Shanhaiguan Pass. The latter, as a transitional company, will be turned into several local companies in about 2 years. In the oil system, it is also planned to set up two companies, the Offshore Oil General Company and the China Oil and Natural Gas General Company. Whether these general companies will be further broken down will depend on the concrete situation after a period of time. Finally, the situation of the nuclear industry system is quite special, and arrangements for it will be made slightly later.

Economically, There Will Be No Subordinate Relationships Between the Ministry of Energy and Various Companies

When asked about the relationship between the Ministry of Energy and various companies, Minister Huang said that economically, there is no subordinate relationship between the two. Each company is an enterprise and it is entitled to powers prescribed by the "Enterprise Law" and the Ministry of Energy will no longer have both the powers of the government and of an enterprise as in the past. It will not directly manage enterprises. Nor will it directly manage funds, goods, and materials. Its functions are to formulate relevant policies and plans, exercise supervision over enterprises, render services to enterprises, and accelerate development of the entire energy industry.

Remaining Personnel Will Run Companies

Will the number of personnel increase or decrease after the four major systems are merged? Decrease, of course, said Minister Huang. The four major systems have about 5,000 people in all. A small number will be transferred to the Ministry of Energy while others will organize companies on the basis of the original departments. What will be done with the remaining people? Their number will not be small. They cannot be "thrown away." We shall ask them to set up new economic development companies. For example, the coal system plans to set up a coal slurry company to develop new technology. This is a good way to make use of surplus personnel and this method will benefit the economy.

The Energy Situation

Changing the subject, Minister Huang said that energy shortage has all along been a factor restricting domestic economic development. However, the present situation is still good.

On the whole, energy output and transportation capacity are increasing. The situation of coal shortage which existed in 1981 ended long ago. During the Sixth 5-Year Plan, half the state investment in railways was used to build special railway lines for coal transportation, thus greatly increasing transport capacity. This year, the special railway line from the Datong Coal Mine to Beijing will be put into operation and it will be extended to Qinhuangdao in 1992. The annual growth rate for electricity is 10 percent. Last year, installed capacity was 8.1 million kilowatts, this year it will exceed 9 million kilowatts, and next year it will reach 10 million kilowatts.

The problem is that the growth of energy supply lags behind the growth of production. Power supply falls far short of demand. The demand for transporting coal from the north to the south is tending to increase again. Oil resources are not abundant. Nuclear power is just [beginning to be] used. How should we make plans for the future? The newly appointed minister said that we had better not speak about things to be done later. The establishment of the Ministry of Energy is intended to accelerate the development of the energy undertaking. As to how this can be achieved, practice will provide an answer.

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Developing Steam/Gas Combined Cycle Power Generation

40130056 Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese No 1, 5 Jan 88 pp 1-10

[Article by the China Electrical Equipment Engineering Society: "Views and Opinions on Development of Steam/Gas Combined Cycle Power Generation in China"]

[Excerpts] **1. Steam/Gas Combined Cycle Power Generation Technologies Are Mature and Have Entered the Stage of Large-Scale Utilization**

Construction of experimental steam/gas combined cycle (CC) power plants began in the 1940's and, after improvement over many years, the technology has become a mature one. According to incomplete statistics, 36 companies worldwide now produce gas turbines, including 24 companies which can provide complete CC generating units. There are more than 47 models with single-unit power ranges of about 1 MW to 200 MW. Since the 1970's, nearly 100 CC generators have gone into service worldwide, and over 20 CC power plants have powers of more than 200 MW. The total power of the No 3 generator of the Niigata Power Plant in Japan is 1,090 MW. It was placed into service in 1985. The two CC generators at Japan's Tosu Power Plant have a total power of 1,000 MW. The first generator began operating in 1986. Japan will place more CC power plants with a total power of 5,070 MW into service by 1993. The Federal Republic of Germany's Gerstein Power Plant is the world's largest CC power plant, with a total power of 2,400 MW. CC generators accounted for 75 percent of the capacity added at thermal power plants during the 1970's in the Federal Republic of Germany. In China, the Taiwan Power Company put two CC generators with a capacity of 287 MW into service in 1983. In addition, countries in the Near East, Middle East, and Southeast Asia have installed several thousand MW in CC generators.

The reason for such rapid development of CC generator technologies is that they have many special qualities:

1. High efficiency. When using a gaseous or liquid fuel and a combustion turbine temperature of 1,154°C, the power supply efficiency can reach 43 to 47 percent. It is hard to exceed 40 percent with large steam generators at

supercritical parameters. The experience of many nations in installing additional combustion turbines and surplus heat boilers to rebuild old power plants was that, when combined with CC generators, power plant capacity could increase by 30 to 40 percent and efficiency by 3 percent.

2. Low investments and power generation costs. Construction costs are about 40 percent less than steam generators. The cost of power generation is 3 percent less than burning heavy oil and 22 percent less than burning natural gas.

3. High reliability. Today's combustion turbines are much more reliable, the working conditions of surplus heat boilers are superior to those of steam boilers, and accident rates are lower. According to 1986 GE Company statistics, the CC generators which the company has produced have a total operating time of nearly 1 million hours, and the average availability rate for CC generators placed in service in the 1970's was 91 percent. Moreover, when one combustion turbine in a CC generator is shut down because of malfunction, the maximum output of the entire unit falls by no more than one-half (when there are two combustion turbines), while the maximum output of an entire generator when a steam turbine has been shut down due to malfunction drops by about one-third, so there is little possibility of losing all output from the entire unit.

4. High operational flexibility. CC generators start up quickly. Only 20 minutes are needed between startup of a combustion turbine and carrying full load. Usually, the entire unit can carry a full load within 3 hours, and less than 1 hour is needed if startup is from a hot state. CC generators also have a rather fast rate of response to load variations, usually as high as 5 to 7 percent/minute. A CC unit generator composed of multiple generators can maintain high efficiency under partial loads via startup and shutdown of different types of generators. Thus, the operational flexibility of CC generators provides very good technology, lifespan, and economic conditions.

5. They save water and take up less land. CC generators consume one-third to one-half less water than equivalent capacity steam generators, and they use 40 to 70 percent less cooling water. They also need much less land. CC generators have short construction schedules and less work is involved in on-site installation. The 320 MM CC generators made by the GE Company are examples. Their combustion turbines can produce 200 MW within 12 to 18 months after they are ordered and the entire unit can reach full output in 20 to 30 months.

China began using combustion turbines in 1960. Between 1960 and 1968, we imported two 6.2 MW generators and copied one 6 MW portable combustion turbine which burned crude oil or heavy oil. These three generators performed excellently. They operated continuously for 1,400 hours and are available 7,000 hours a year. Eight series MS5000 combustion turbines were imported in 1973. Four were installed in north China, one in northeast China, and three in east China. They burned light diesel oil and were used as peak regulation and emergency reserve generators in power grids. The designs of certain components and flame tubes in this group of generators took into consideration their short lifespan. Fixed costs at base loads were too high with two of the PG5331 units. Added to the insufficient attention given to air and fuel oil cleanliness at the time, components wore out quickly, repair costs were high, and there were many malfunctions for a period of time at the start. These were solved rather quickly, however. In 1976, two more Japanese-built PG5301 generators went into operation and their operating conditions were rather good throughout.

Table 1 provides some operational data up to the end of 1985 for 6 of the 10 MS5000 generators.

Table 1. Operational Data for MS5000 Generators From Time of Going Into Service to the End of 1985

Name of power plant	Generator model x number of units	Year placed into service	Total hours of operation	Total power output (x 10^6 kWh)	Number of start-ups	Actual power output at startup (percent)	Average yearly availability rate (percent)
Beijing No 3 Thermal Power Plant	PG5331x2	1973	61,590	101.27	5,765	95	85
Longfeng Thermal Power Plant	PG5301x1	1974	27,891	46.21	2,513	--	--
Nanjing Zibei Thermal Power Plant	PG5301x1	1977	10,873	18.32	2,911	--	--
Beijing No 1 Thermal Power Plant	PG5301x1	1977	24,658	35.88	3,389	98	94.5

In another area, China also has imported generators with serious design and manufacturing defects. The GT-120 generator imported from Sweden, for example, suffered many malfunctions after going into service and output was inadequate. This showed that the reliability of combustion turbines is guaranteed by selecting mature generator models and using rational operation, maintenance, and management.

After the early 1980's, several combustion turbines were shut down due to fuel policy restrictions. However, the power shortage has become increasingly apparent following the development of China's national economy and there are severe power shortages in oil fields and certain newly developed cities. As a result, several combustion turbines and CC power generation and power/heat cogeneration units with a total power of 695.5 MW were imported before and after 1985 from England, the United states, and France. They included two power heat cogeneration units with a total power of 59.5 MW and a power generation efficiency of more than 65 percent, eight CC power generation units with a total power of 466 MW and a power generation efficiency of more than 42 percent, and seven combustion turbine power generation units with a total power of 170 MW and a power generation efficiency of about 27 percent.

It is apparent from the above that although the average capacity of these eight CC generators is only 58 MW, their efficiency surpassed steam generators at supercritical parameters.

China also has worked on land-based ship propulsion turbines installed on small power/heat cogeneration or CC power generation generators.

III. The Necessity and Feasibility of Developing Coal-Burning Combined Cycle Power Generation in China

China has extremely rich coal resources and ranks third worldwide in coal production. Thus, thermal power generation must take the coal-fired path. This energy policy is determined by China's national conditions. Thermal power plants are major coal burners and the amount of coal burned in them has continued to grow as the electric power industry has expanded. China used 170 million tons of coal for power generation in 1985, and it has been calculated that 2.7 million tons of SO_2 are emitted into the atmosphere each year. Estimates are that the amount of coal burned for thermal power will exceed 400 million tons a year by the end of this century, and the increase in SO_2 emissions will exceed the growth in the amount of coal burned. China basically is a continental nation. Although it has a large population and vast territory, industrial regions are relatively concentrated and areas which have experienced acid precipitation in recent years have seen an obvious increase in the extent. Some regions have been severely affected. Stronger control over SO_2 and NO_x emissions is essential. If we wait until we are punished by nature to control them, the losses will be even greater.

Very large investments and operating costs are required to deal with SO_2 and NO_x emissions, and the long-term power shortage has become a prime obstacle to the socialist four modernization drive. The electric power industry must concentrate its manpower, finances, and materials to expand power generation capacity. This also is feasible within the permissible scope of administrative and legal provisions adopted by the state in response to environmental demands. Given the path taken by the industrialized nations and China's real conditions, atmospheric quality which is deteriorating daily will force the state to make new decisions soon on atmospheric emissions, and the electric power industry must prepare for this by taking note of developments in new technologies and taking action at the appropriate times.

The amount of coal consumed for thermal power generation in China continues to be as high as 428 g/kWh, which is 50 to 100 g/kWh more than the main industrial nations of the world. In the area of energy demand, yearly power output in China will surpass 1.2 trillion kWh in 2000, quadruple the 1980 figure. The rate of growth in thermal power will be slightly faster than the overall rate of growth, but coal output over the same period can only double, so a major effort is needed to increase the thermal efficiency of thermal power. We must take note of the development and utilization of new power generation technologies, and choices can be made in energy plans for the 21st century.

The United States Department of Energy and the Electric Power Research Institute have given continual attention to the development of coal-fired CC. The alleviation of the petroleum crisis and the sharp drop in oil prices have not slowed them, and the main goal in the United States remains IGCC. The Federal Republic of Germany also has experimented with PFBC CC power plants. While establishing large CC power plants which burn natural gas, Japan also has studied development of combustion turbines with gas intake temperatures of 1,500°C to achieve even greater efficiency in future IGCC power plants, and some large companies have begun engineering research on IGCC power plants. This sort of direction in the industrially developed nations is based on a consideration of long-term technical economics strategies for energy resources. The energy strategy research report issued in late 1984 by the Central Electric Power Research Institute (CRIEPI) of Japan's International Electric Power Technology Exchange Commission (IERE Council)[8] is quite representative. The report pointed out in its chapter "Now Is the Time To promote Promising Advanced Power Generation Technologies" that: "After the year 2000, advanced coal-fired power generation technologies will come into use, and among them coal-fired CC, supersupercritical steam power plants, and molten silicate fuel batteries will completely replace conventional coal-fired power plants. Moreover, while continuing to burn a certain amount of natural gas, natural gas CC power generation will replace conventional natural gas power plants." Japan's "Sunshine" and "Moonlight" plans also treat coal-fired CC as the primary new technology for power generation. It is obvious that all the main industrialized nations have great hopes for CC power generation technologies and see them as the primary new technologies for conventional power generation after the year 2000. It should be noted that this understanding is based on the results of a large amount of research and experimentation, including intermediate testing and industrial experiments, so it is rather reliable and can be borrowed from.

Several things in China favor development of coal-fired CC. There is no need to mention our rich experience in manufacturing and operating steam power generation equipment, including intermediate, sub-high, high, or super-high pressure turbines and generators. In the area of gas-fired power generation, China has specialized manufacturing plants and research organs for heavy combustion turbines and we have produced series 5000 combustion turbine units. We now are cooperating with the GE Company to produce series 6000 combustion turbines, and we have made plans to produce series 9000 combustion turbines. These combustion turbines can be matched with 60, 110, and 230 MW IGCC power generating systems. China also has enormous strengths in light combustion turbine manufacture and research. There have been developments and achievements in recent years in the use of aircraft turbines. We also have accumulated substantial experience on combustion turbine operation and maintenance, and we have trained many mature technical personnel and technicians. In the area of surplus-heat boiler manufacture, China has selected plant sites to import foreign technologies for specialized production. In the areas of coal gasification, China has cooperative relationships with the KRW Company and Lurgi Company to manufacture new types of coal gasifiers. Texaco gasifiers also are being imported and research departments have new types of experimental gasifiers, so new coal gasifier technologies are entering China. In addition, several achievements have been made in pressurized fluidized-bed combustion experiments. All of these things are an invaluable foundation for the development of coal-fired CC power generation.

It is both necessary and feasible for China to develop coal-fired CC power generation, so when should the first steps be taken?

The Suzhou Coal Gasification Combined Cycle Industrial Experiment Plan was formulated in 1987, but because the second generation of coal gasifiers had not arisen at the time, our only choice was to select the second all-out war stage for Lurgi gasifiers. Conditions were rather poor and there were several negative factors in many areas. As a result, this plan was scrapped, but progress still was made in technical research on the basis of coal-fired CC. Examples include the technology in GE-series heavy combustion turbines which burn low calorific value coal gas (100 kcal/Hm^3) (the Shanghai Power Generation Equipment Complete Unit Design Institute is cooperating with the GE Company), pressurized fluidized bed boilers and the corresponding high temperature flue gas purification technologies (Nanjing College of Engineering), direct combustion of clean pulverized coal (Nanjing Gas Turbine Institute), and other areas, where smooth progress is being made and stage achievements have been made. In another area, chemical industry, metallurgical, and machine manufacturing departments in China have worked on new types of coal gasifiers, and they have signed agreements for cooperation in producing new types of coal gasifiers and industrial experiments. These things show that China has prepared an excellent foundation for developing complete goal gasification CC power generation industrial experiments. There would be several advantages if we were to begin now with imports or by cooperating with foreign companies to use the large number of achievements they have made in intermediate testing and industrial experiments: We could catch up, save time, and make good preparations for power generation technologies after 2000. If we start now, predictions are that they could begin operating in 3 or 4 years. By 2000, we could accumulate sufficient direct experience to put together IGCC generators with Chinese features. This course would lag 8 to 10 years behind the United States and the Federal Republic of Germany, but there would be less difference in levels. As the initial temperatures of combustion turbines rise, CC efficiency also would increase. Moreover, there would be many economic advantages and few disadvantages to starting now. The slump in petroleum prices over the past several years has meant a lack of direct economic motivation to convert oil-fired power generation equipment or oil-fired power plants to coal burning on a global scale. Although some new coal gasifiers have attained mature use as industrial or civilian coal gas production equipment, they have not been put through industrial experiments for power generation, nor have they fully entered the commercial stage. Thus, imports and cooperation would cost less, the conditions would be more advantageous, and it would be easy to obtain core technologies. If we wait until after foreign nations have put them into full service and extend them on a large scale before we import them, our counterparts would want a higher price and the terms would be harsher. This can be expected, and Chinese technologies would be even more backward, which would make assimilation more difficult. Another thing to consider is that many industries in China have imported new types of coal gasifiers, but the purity requirements for industrial and civilian gas are lower than combustion turbines. For this reason, when China produces its own new types of coal gasifiers, they still will not be able to be used immediately for companies power generation. We must at least start with coal gas scrubbing and total power plant control technologies, which would encourage understanding, extending, and utilizing IGCC technologies in China.

In the area of strategic deployments for S&T development, it is extremely important that opportunities not be missed. This is especially true for power generation equipment (and technologies). In a situation of ever-higher demands for energy conservation and environmental protection, a lack of technical reserves would force us to spend an enormous amount of money during rapid development of the electric power industry to construct backward facilities, and the loss would be hard to calculate clearly.

In summary, the conditions are mature and there is a definite need for China to begin industrial demonstration experiments with coal-fired CC during the Seventh 5-Year Plan and the time is right now.

IV. Concrete Proposals

1. As for how to achieve industrial demonstration experiments with coal-fired CC during the Seventh 5-Year Plan, I propose that:

First, we should make every effort to utilize China's existing conditions and foundations and take the first step by using the least amount of investments and shortest amount of time to build a complete IGCC power generation demonstration generating unit. This is the most realistic method for achieving greater, faster, better, and more economical results.

The Beijing No 3 Thermal Power Plant is located in the suburbs of the capital. It has two series 5000 GE 21.7 MW gas turbines and three 12 MW steam turbines imported during the 1970's, and it has a complete coal reserve system. Coal gasifiers were installed between the coal yard and the gas turbines, and between the gas turbines and steam turbines, and there are more than enough surplus heat boilers. This plant also has rich operating and management experience with gas turbines and steam turbines.

As mentioned above, the KRW coal gasifier is a type of fluidized bed gasification facility imported from the Westinghouse Company in the United States. It can gasify all types of coal. The intake coal has a particle size of 0 to 6 mm, the slag is neutral coacervated ash, and it can use air, oxygen-rich air, or oxygen as the gasification agent. The coal utilization rate can reach 95 percent, the thermal efficiency of gasification is 70 percent, and it has a wide range of load regulation. It produces no tar and only a small amount of acids and other pollutants which can be controlled. It does not pollute the environment, and the investment costs and operating costs are obviously lower than Texaco gasifiers. It is an appropriate type of gasifier for use in CC power generation. Construction has begun at the Cairnbrook Power Plant, the United States' second IGCC demonstration power plant, and it is expected to go into service in 1989. It uses this type of gasifier as its coal gas source. China's No 1 Heavy Machinery Plant has signed a contract with the United States' Kellogg Company to construct a KRW coal gasification industrial demonstration facility in China, and we expect to receive the equipment used in the industrial demonstration experiment facility in 1988.

If we make full use of the conditions already prepared at the Beijing No 3 Thermal Power Plant and the Fulaerji No 1 Heavy Machinery Plant, create a unit between the existing gas turbine generator and steam turbine generator at the Beijing No 3 Thermal Power Plant, and establish the first KRW coal gas gasifier produced by the Fulaerji No 1 Heavy Machinery Plant at the Thermal Power Plant, and if we outfit it with a surplus-heat boiler to complete China's first 30 MW-grade IGCC power generation industrial demonstration experimental facility, the investments would be the least and the construction schedule the shortest. After this part of the equipment at the Beijing No 3 Thermal Power Plant is rebuilt, there is hope that the efficiency may rise to 30 to 32 percent, meaning that it would reach the efficiency level equivalent to a 100 MW steam generator. If combined with regional heat supplies and greater amounts of heat supplied, the average efficiency would be substantially increased, and it would provide rather good economic benefits in the areas of increasing annual power output and the amount of heat supplied, and in conservation of oil and coal.

If we substitute completed sets of new IGCC equipment imported from foreign countries for this method, there would be a substantial increase in project investments, and we would be forced to delay them for quite some time. In the areas of developing new reserve technologies matched with China's electric power industry in the 21st century and accumulating our own experience, the rate of progress also would be greatly delayed. As for the question of the level of equipment to be adopted for IGCC, as outlined above, the KRW goal gasifiers we are preparing to use have been chosen by the United States to serve as the gasifier type used in the second IGCC industrial demonstration power plant. It should be said that on a world scale at present, the technologies are rather advanced. Efficiency levels would of course be slightly lower with the existing series 5000 GE gas turbines but the goal in building this type of IGCC industrial demonstration experiment facility is to grasp as quickly as possible core technologies like coal gasification, coal gas purification, system control and regulation, automatic protection, low calorific value coal gas for burning in combustion turbines, resistance to blade wear and corrosion, and so on. This would provide experience for construction of IGCC which is even lower to world levels, so using existing combustion turbines does not preclude attainment of the goal. Moreover, the startup of this IGCC industrial demonstration experiment facility would enable us to determine the efficiency levels attainable by IGCC after adopting combustion turbines with even higher intake gas temperatures. Thus, it should be said that this is the most desirable realistic method.

Second, the essence of the projects related to this does not involve only scientific research, nor is it entirely a common capital construction project. Technologically, it touches on several industries and many specialized categories. At present, no single industry or enterprise unit is capable of taking on this project independently. Thus, since the project has a heavy technical development quality and a long period of trial operation, it would be possible that several revisions and so on would be required, which can be expected. If construction of this project is funded through normal loans for project construction, repayment of the loans would become a problem in the enterprise. As a result, in the area of organizational leadership, the relevant state ministries and commissions should reinforce leadership and establish a multi-industry authority to lead the way and assemble forces in the relevant departments under leadership by the relevant state ministries and commissions, with a multi-departmental division of labor and responsibility in an integrated war to push forward. In the area of investment sources, the state should provide the appropriate financial assistance. They also should work actively to collect investments from the relevant enterprises and use joint investments to develop this new clean coal-fired power generation technology.

2. Make macroeconomic benefits the starting point, adapt to local conditions, work to develop CC power generation and CC power/heat cogeneration. In decentralized regions with oil fields that have associated gas resources or where natural gas resources cannot be transmitted for the time being, as well as in new economic development zones in coastal areas, attention can be given to establishing gas fuel or liquid fuel CC power generation and power/heat cogeneration when there are high product exchange rates and severe power shortages. Some can be converted to coal-fired generators in the future based on resource situations and the extension of coal-fired CC technologies. China has

already started this method and rather good results can be obtained, so it should be continued.

3. At present, China still has several oil-fired generators which are generating power. State plans for 1986 allocated about 12 million tons of oil for power generation, and some of the oil-fired generators will continue operating for some time. The Nanjing Zibei Power Plant is an example. It has two PG3501 combustion turbines with an output of 21.7 MW which are used to peak regulation operation, and they generate (0.3 to 0.47) x 200 million kWh per year. Calculated at 0.3 x 200 million kWh, a conversion to burning heavy oil would save 9.46 million yuan in oil and the power cost would drop from 0.4 yuan/kWh to 0.242 kWh. If the combustion turbines at this plant and the 10 MW steam turbine at the Xiaguan Power Plant (with an oil-fired boiler) are used to form CC power generation generators which operate for 5,000 hours a year, each CC unit composed of a combustion turbine and a steam power generation generator could produce 145 million kWh, and the power cost would drop to 0.14 yuan/kWh. This would help alleviate the power shortage in Nanjing city. Moreover, this transformation project would require only the addition of heavy oil processing equipment and surplus-heat boilers. Limited investments would be necessary. By calculating an electricity price at 0.223 yuan/kWh (minus the 0.22 yuan/kWh cost of connecting to the grid), the yearly profits would be about 12 million yuan and the entire investment could be recovered within 2 to 3 years. The socioeconomic benefits and the economic benefits to the enterprises would be good. I propose that the relevant areas given attention and support to power plants in this sort of situation.

4. Pressurized fluidized bed technologies (PFBC) have advantages including rather simple equipment, adaptability to a wide range of coal types, high efficiency, and so on. A PFBC boiler added to a gas turbine and the original steam turbines to form CC power generation also is a rather hopeful new program for high efficiency and low pollution coal burning technologies. Refitting now is underway at the Tidd Power Plant in Ohio in the United States, the Escatron Power Plant in Spain, and the Vartan Thermal Power Plant in Sweden. They will go into service around 1990 to conduct industrial tests.

China has rather rich experience in the area of fluidized bed combustion industrial boilers, and we have made several achievements in PFBC experimental research, so we have a rather good beginning, and I propose that we continue to expand experimentation on these foundations.

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12539/9365

BRIEFS

ENERGY OUTPUT INCREASES--Beijing, 9 April (XINHUA)--China's energy industries made steady progress in the first quarter of this year. According to statistics from the State Statistical Bureau, the electric power industry is developing rapidly. It generated a total of 129.1 billion kWh of electricity in the first quarter, up 12.7 percent from last year's corresponding period and showing the fastest increase of recent years. In the first quarter, China's raw coal output was 205 million metric tons and its crude oil output was 33.64 million metric tons, up 2.9 percent and 3.2 percent respectively from last year's corresponding period. [Text] [Beijing XINHUA Domestic Service in Chinese 0623 GMT 9 Apr 88] 40130077 /12858

BRIEFS

EAST CHINA GRID CONSTRUCTION--There is a surge of capital construction in the energy-starved East China Grid. This year, ministry-affiliated capital construction funding is 3.6 billion yuan and plans call for putting on stream 15 units with a generating capacity of 1.801 million kilowatts, the largest amount ever. As of the end of January of this year, work has begun on 52 units [with a capacity of] 1.0628 million kilowatts; this figure includes the 15 units scheduled for completion this year. These [generator] units are being installed in Shanghai's Shidongkou, Jiangsu's Yangzhou and Nantong, Zhejiang's Taizhou and Jinshuitan, Anhui's Bangbu and other power plants and stations as well as local enterprise power facilities. The scale of this year's power projects (and their associated transformer and transmission infrastructure) in the East China Grid is pretty ambitious, with 560 kilometers of 500 kV high-tension lines and 1.25 million kVA of transformer equipment being installed. Also slated for completion this year are the 500 KV AC power transmission line from Huainan to Shanghai and Xuzhou to Shanghai and the 500 KV DC transmission line from Gezhouba to Shanghai. [Text] [Shanghai WEN HUI BAO in Chinese 21 Feb 88 p 1] 40130072/9365

Construction Program for Hydropower Sector in 1988 Reviewed

40130057 Beijing SHUILI FADIAN [WATER POWER] in Chinese No 2, 12 Feb 88 pp 1-2

[Article: "Capital Construction and Preliminary Work Mission Program for Hydropower in 1988"]

[Excerpts] In 1987, with a heavy workload and many difficulties, China's hydropower construction made great achievements, reaching three historically high levels in terms of overall annual rated capacity for hydropower (2.03 million kW), annual rated capacity of a single hydropower station (Gezhouba 750,000 kW) and the number of sets installed in a hydropower station in a year (Gezhouba with six 125,000 kW generator sets; at the same time, rivers were dammed for five large and medium-sized hydropower stations. Up to the end of last year, 12.4755 million kW of hydropower projects were under construction in China. This figure includes projects which have just been added to the state plan and for which construction preparations are fully underway; whose main projects are about to enter peak construction, those for which installation and going into production should continue or the first generator should begin generating power, and those whose construction has been finished and are being checked before being handed over. After the National Hydropower Planning Capital Construction Conference convened by the Ministry of Water Resources and Electric Power in mid-December [1987], the editorial department of this journal asked the relevant ministry departments in charge how they understood the 1988 hydropower capital construction and preliminary planning work preparations and the demands on relevant units. A summary is provided below:

(1) Hydropower capital construction program

The hydropower capital construction work for 1988 should conduct reform of the entire situation and, while ensuring construction safety and quality, stress project results, promote technological progress, reform management systems, stress flood prevention and power generation, and strive to complete the annual plan overall.

1. Completing the task of putting 19 units with a total capacity of 1.66 million kW at 11 projects into production in 1988. This includes the five new projects of Lubuge (1 x 150,000 kw), Shitang (1 x 26,000 kW), Laohuxiao (1 x 65,000 kW), and Xiaodongjiang (2 x 7,000 kW) and the ongoing project at Gezhouba (4 x 125,000 kW), Longyangxia (1 x 320,000 kW), Dongjiang (2 x 125,000 kW), Shaxikou (1 x 75,000 kW), Jinshuitan (2 x 50,000 kW), and Tohai (2 x 12,500 kW).

2. Stress flood prevention to ensure that construction is not hampered during the high-water season. The lessons of past projects which have not completed high-water transition construction on time so that foundation excavations have filled with water thus delaying the project should be conscientiously studied, plans made as early as possible, and effective measures formulated to stay ahead of the 1988 floods. For the five projects which dammed rivers last year, the flood prevention task for 1988 will be difficult. Final stage work involving civil construction at the Jinshuitan, Dongjiang, Longyangxia, and Shaxikou projects should include improved transition standards for 1988.

3. Stress river-damming and accelerate construction. Projects for which river-damming is planned in 1988 include Wuqiangxi, Dongfeng, and Wan'an and construction should be organized accordingly. Preparatory work for the Baozhusi project should be done thoroughly to set the stage for damming in 1989. Power generating measures should be implemented on schedule from the second stage of the Tianshengqiao project. Construction of the Ankang project should be accelerated by every possible means. For the Tongjiezi project, generator unit order contracts should be signed, gate valve proposals determined, and measures for foundation handling taken to create conditions for generating power in 1990.

4. Completion of projects should be stressed, and finished construction checking and acceptance preparations made. This should be stressed on the Baishan first stage, Hongshi, Taipingwan, Yuzixi second stage, Xi'er He third stage, and Gezhouba projects. Furthermore, preparatory work should be done according to state regulations in anticipation of completion of construction, and checking and acceptance.

(2) Preparations for hydropower project early stage work

In 1987, subordinate survey and design units completed their missions well, providing technical support for projects under construction; a great deal of preparatory work was done so that such new projects as Geheyan, Lijiaxia, and Ertan could start construction smoothly. Projects such as Tianshengqiao first stage, Daguangba, Shisanling pumped storage, and Daxia met conditions to become part of the annual capital construction plan. The planning and site selection reports for several rivers and river sections were completed. On the basis of these achievements, relevant survey and design units should strive to do the following in 1988:

1. Guarantee key projects, complete preparatory work, and increase plan reserves. Hydropower projects for which preliminary planning had been completed include Longtan (5 million kW), Wanjiazhai (1.08 million kW), Xiaolangdi (1.56 million kW), and Guangzhou pumped-storage (1.2 million kW); the hydropower projects for which feasibility studies have been completed are Sanxia "175 m elevation" (17.58 million kW), Baobugou (2.8 million kW), Datengxia (1.2 million kW), Pengshui "Long Creek" (1.2 million kW), Gongboxia (1.1 million kW), and Longkou (400,000 kW).

2. Improve planning work and complete hydropower development plans. While making river, river section, and project plans, regional hydropower development plans should be improved to provide proposals and technical and economic verification for projects on which construction will begin during the latter part of the Seventh 5-Year Plan and during the Eighth 5-Year Plan. On the basis of regional economic development, power demand and local needs, site selection for medium-sized hydropower stations should be carried out and construction of medium-sized hydropower stations accelerated.

3. Continue to provide technical expertise and carry out consulting service work. For projects under construction, the necessary design drawings should be promptly supplied, construction should be closely coordinated, and flood prevention work should be carried out to ensure the smooth progress of the project. For projects just getting started, bid documentation should be promptly provided and consulting services should be carried out.

4. Water conservancy and hydropower planning, surveying, and construction should be improved, sound economic thinking should be established, revision of regulations and standards should be accelerated, large-scale computer software should be developed, and technology, planning, and financial management systems should be improved.

8226/9365

BRIEFS

WAN'AN UPDATE--The Wan'an hydroelectric power station is a major construction project of the Seventh 5-Year Plan. After its completion, the station will ease the power shortage in Jiangxi Province and promote industrial and agricultural growth. As of the end of February 1988, the station's ship lock (on the right bank of the Gan Jiang), powerhouse, lower sluice gates, and other major parts of the project were 80 percent completed with some 940,000 cubic meters of concrete having been poured. progress had been made relocating the populace from the impoundment zone and preparatory work has been done for large-scale power generation so that the project can go on stream before 1 October 1989. [Excerpt] [Nanchang JIANGXI RIBAO in Chinese 11 Mar 88 p 1] 40130069/9365

GUANGZHOU PUMPED-STORAGE STATION APPROVED--Construction on the Guangzhou pumped-storage hydropower station--a joint venture involving the government of Guangdong, the Ministry of Water Resources and Electric Power, and the Ministry of Nuclear Industry--has been given the formal go ahead by the State Council. The first stage of this power station, located in Conghua County, will have a capacity of 120,000 kilowatts. In a recent meeting of the three participating parties chaired by Guangdong Deputy Governor Kuang Ji, construction plans were decided upon and board chairman and general managers elected. Construction will begin as soon as possible and the station will be built concurrently with the Daya Bay Nuclear Power Plant; an effort will be made to put the two projects into production at the same time to meet the power demands of Guangdong. [Text] [Guangzhou NANFANG RIBAO in Chinese 17 Feb 88 p 1] 40130068/9365

Potential of Small-Scale Thermal Power To Narrow Energy Gap Discussed

40130065 Beijing RENMIN RIBAO in Chinese 1 Feb 88 p 5

[Article by Wang Quanshu [3769 0356 2579]: "The Feasibility of Developing Small-Scale Thermal Power"]

[Text] An electrical power shortage is one of the main factors which restricts sustained stable development of the national economy. For many years, the power shortage has had considerable effect on both industrial and agricultural production in all areas of China and there are severe household power shortages in many regions. It is not merely that this situation has continued for many years. Even more important is that there is no possibility of a fundamental turnaround in the near term. Nevertheless, if policies are correct and measures appropriate, it will be possible to alleviate the power shortage situation more quickly. I feel that while the state is engaged in a major effort to build several large-scale hydropower and thermal power stations in a planned manner, another feasible measure is to build several small-scale thermal power stations in certain coal producing regions as local conditions permit. If utilized properly, they could play an important auxiliary role in alleviating the national power shortage. The development of small-scale thermal power according to local conditions similar to the development of small-scale hydropower in some rural areas of southern China would play an obvious role in providing a quick solution to the power shortage in medium and small-sized cities in certain coal producing regions.

China has rich coal resources and more than 10 important coal producing regions. A push to develop several small-scale thermal power stations near certain coal mines in certain provinces and autonomous regions would be very economically sound. This can be analyzed from many perspectives.

1. The Perspective of Coal Resources

Henan Province can serve as a single example. Henan has nearly 100 local state-run coal mines and more than 2,000 township and town coal mines. In 1987, Henan had more than 9 million tons of overstocked coal and marketing departments had overstocks of 3.8 million yuan. If several small-scale thermal power stations were developed according to local conditions, they could make use of resource advantages and convert the coal locally into electricity to increase its value. This could satisfy local demand for electricity, and it could eliminate coal overstocks, promote coal production, and reduce the pressure on coal outshipments. Jiangsu Province, which lacks coal resource advantages, has built small-scale thermal power stations of about 300,000 kW altogether in the past 2 years, and they have played a relatively important role in alleviating shortages of production and household electricity throughout the province. Jiangsu's experience is very enlightening.

2. The Perspective of Construction Schedules

It takes 4 or 5 years to build a large power plant and put it into operation. A 6,000 kW thermal power plant, however, can be finished and put into operation in the same year. Only a little more than 1 year is needed between groundbreaking and power generation with a 12,000 kW thermal power generator unit, so small-scale thermal power has the big advantages of being "short, simple, and fast."

3. The Perspective of Project Cost

A small-scale thermal power project costs about 1,180 yuan/kW to build, while the average cost of building a large power plant is 900 yuan/kW, so the cost of small-scale thermal power construction is 190 yuan/kW higher than large-scale power plants. However, large power plants require high-voltage transmission lines, so the overall cost of constructing them is not very low. For example, the total cost of the additional installed generating capacity in the Central China Grid during the Sixth 5-Year Plan was 1,954.7 yuan/kW, and the total construction costs for new generator units which the state planned to put into operation during the Seventh 5-Year Plan was 1,860 yuan/kW. Local small-scale thermal power, however, is generated and supplied locally, so very few outside investments are needed for the projects. Thus, the overall costs are less than large-scale power plants. Development of small-scale thermal power in coal producing provinces nd autonomous regions also is much more economical than buying rights to power from the stage outside of unified distribution power quotas based on a total construction cost of 2,500 yuan/kW, and it can make a contribution toward assisting the state in alleviating the national power shortage.

4. The Perspective of Power Generation Costs

Henan again can serve as an example. The average cost of power generation at small-scale thermal power stations in Henan during 1987 was 0.0672 yuan/kWh. The average selling price of the electricity, not including taxes on power supply links, was 0.0781 yuan/kWh. These figures included average power generation costs of 0.0593 yuan/kWh at small-scale thermal power stations of 6,000 kW and up, and an average selling price, excluding taxes on power supply links, of 0.0698 yuan/kWh. Ministry-run large-scale thermal power plants have an average power generation cost of

0.0444 yuan/kWh and an average selling price of the electricity of 0.0714 yuan/kWh. Excluding taxes on power supply links, the average selling price of the electricity was 0.0659 yuan/kWh. The cost per kWh for power from a 6,000 kW small-scale thermal power station is only 0.01496 yuan higher than the cost of generating power in grids, and the selling price is only 0.00393 yuan higher. At the same time, power generation costs at the Dengfeng small-scale thermal power plant are 0.041 yuan/kWh and electricity is supplied to the grid at 0.0663 yuan/kWh, so the cost of power generation and the selling price of the electricity both are lower than ministry-run plants.

5. The Perspective of Macroeconomic Returns to Investments

When a country spends around 20 million yuan for a 12,000 kW thermal power generator, figuring the yearly power output to be 70 million kWh, it can create about 150 million yuan in value of industrial output and more than 20 million yuan in taxes. As for the current situation in Henan Province, each deficit of 1 kWh reduces the average value of industrial output in Henan by 2.35 yuan. If the shortage of power for industrial uses throughout Henan mentioned above could be supplemented with small-scale thermal power, the value of output in existing enterprises would increase by more than 10 billion yuan.

6. The Perspective of Technical Forces

All areas are capable of dealing with the technical forces required to build small-scale thermal power. Every region has accumulated successful managerial experience in running small-scale thermal power and they have a very broad range of technical forces. Most counties can depend on their technical staffs for everything from installation through debugging.

7. The Perspective of Equipment Service

A small-scale thermal power plant can provide at least 25 to 30 years of service. Generally, only 3 to 5 years are needed to recover the investment and the loan repayment period generally is 6 to 8 years. This means that within 10 years, the rather high investment-profit rate during the investment process can be terminated successfully. Moreover, the state and enterprises also benefit during this period, and industrial and agricultural production receive considerable benefits. Moreover, small-scale thermal power equipment enters its "mature years" after 10 years and can play an obvious role in the economic development of the region for 10 or 20 years more. We should not say that it will be hard to alleviate the national power shortage within 10 to 20 years. We should step back instead and say that there still is a great deal of room for small-scale thermal power to alleviate the power shortage. For example it can be used as a source of reserve power for industry, for peak regulation or converted for phase regulation, for drilling for natural gas as a source of heat, for supplying heat with low vacuum cycled water, and so on.

8. The Perspective of Preferential State Policies for Development of Small-Scale Thermal Power

In 1987, with approval by the State Council, the State Planning Commission and Ministry of Water Resources and Electric Power issued a joint document stipulating several preferential policies for the development of local small-scale thermal power. For example, local state-run independent accounting small-scale thermal power plants which went into operation during and after 1986, including generating units for expansion of small-scale thermal power plants, can be exempted from income taxes and regulation taxes. The profits earned in small-scale thermal power plants are not included in local fiscal budgets. After the loan is repaid, all profits are used to develop small-scale thermal power and small local power grids. After small-scale thermal power plants are connected with grids, they have no effect on the original distribution of power use indices in the regions, departments, and units of a large power grid, and so on. Preferential economic policies for the development of small-scale thermal power, which long have been a hope, now have been formulated. Why have areas with the proper conditions still not taken action?

9. The Perspective of the Initiative of Cities, Prefectures, and Counties To Operate Small-Scale Thermal Power

Recently, a major headache and central problem for party and government leaders in many cities, prefectures, and counties has been a lack of power, wrangling over power, hoping for power, thinking of power, demanding power, and managing power, especially accelerating the pace of small-scale thermal power construction. The clamor for setting up small-scale thermal power has been the loudest in those cities and counties with vigorous city, county, township, and town-run coal producing enterprises, in cities and counties which formerly had small-scale thermal power, and in cities nd counties at the far end of power grids. This initiative also is an extremely favorable condition for rapid development of small-scale thermal power.

In summary, a major effort to develop small-scale thermal power is urgently needed. It is economically rational, and [local areas] can build and manage the plants themselves, they can generate and use their own power, they have decision-making rights concerning production rights and power utilization rights, and the power of initiative is in their own hands. Moreover, they do not affect unified distribution standards in grids, it can be said that the opportunity and geographical advantages exist and that the people fully support them, so why should regions with the right conditions not be interested?

Raising funds is the key question in a major effort to develop small-scale thermal power. Several 10 million yuan of investments are needed to build a small-scale thermal power plant. Although most cities and counties are willing to bear the brunt of the cost, the relevant provinces and autonomous regions still should provide the needed financial assistance and lend a hand. If we broaden our ideas and expand channels, the needed financial support from the relevant provinces and autonomous regions can be put together. The key is that everyone must have the determination.

12539/9365

BRIEFS

LIUZHOU EXPANSION PROJECT--The State Planning Commission a few days ago agreed upon the expansion project for the Liuzhou power plant (two 200,000-kW generator sets). The total investment will be in the neighborhood of 400 million yuan. When the entire project has been completed and put into operation, the plant's power generation capacity will have increased 10-fold. The feasibility study report and the environmental impact statement for the expansion project were reviewed and approved in late February. The construction will get underway this year and be completed in 1991. [Text] [Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 31 Mar 88 p 1] 40130064/9365

Coal Industry Faces Major Problems in Extraction, Shipping, Pollution

40130071 Beijing BEIJING KEJI BAO in Chinese 2 Mar 88 p 3

[Article by Tang Dequan [3282 1795 0356], Academy of Coal Science, Ministry of the Coal Industry: "The Three Major Problems of Coal Industry Development"]

[Text] According to China's development strategy, total national output value will double by the end of the century and the people will be relatively well off. By the middle of the next century, per capita output value will be that of the moderately developed countries, the people will be prosperous, and modernization will have been essentially accomplished.

The mid- and long-term energy requirements that spring from these objectives are very great: about 1.4 billion tons of standard coal in the year 2000, about 3.4 billion tons in 2030, and about 5.6 billion tons in 2050. If we assume that coal will account for respectively 70, 60, and 50 percent of these figures, then the amounts of raw coal required will be 1.4, 2.9, and 4.0 billion tons. Coal requirements of this magnitude will involve major difficulties for the coal industry. To assure the needed supply of coal, it will be necessary to solve three major problems, namely, deep-mine coal extraction, coal transport, and coal pollution, by making sure of scientific and technical progress.

1. Deep-Mine Extraction

Economic growth is putting increasing pressure on the coal supply, and the depth of the mines in which coal is extracted will increase continually. The average extraction depth is now about 350 meters; it must be increased by about 10 meters a year, with attendant increases in rock pressure, gases, percolation water, and hydropower, so that extraction conditions will worsen rapidly, and investment per unit output and production costs will rise steadily. Because of the limited space in underground coal mining, an increasingly dangerous working environment, and continually changing production conditions, China's coal industry is labor-intensive by world standards. The long-term development of coal production must rely on scientific and technical progress, make use of the scientific and technical advances, and make the changeover from the low technology to high technology; otherwise it will be difficult to achieve large increases in output safely and efficiently in the face of complex, changeable production conditions, and a worsening coal mining environment.

Integrated mechanization of coal extraction was the first revolution in modern coal technology; it is universally recognized and has been instituted in the advanced coal-producing countries. In China the degree of integrated mechanization is only about 25 percent, so that the problem of having to increase output with no increase in personnel has not yet been fundamentally corrected.

The second technological revolution in the coal industry should be computer-based mine automation, including the use of microcomputer technology in mine system monitoring and the utilization of CAD and CAM. The experimental use of optical fiber communications and industrial robots will pave the way for computer-controlled automated mines. Advanced coal extraction technology, new technologies for underground coal gasification and liquefication, and new chemical coal extraction methods such as chemical fracturing and biochemical decomposition are still in the experimental or exploratory stage, and it is hard to predict whether they will come into use in the next century.

Coal chemical engineering technology based primarily on surface gasification and liquefication of coal will be the third revolution in coal technology. World coal reserves far exceed those of petroleum and natural gas, and an energy structure based primarily on coal will continue. Although the use of hydroelectric power, nuclear power, and other renewable energy sources will expand, coal conversion technology will make major breakthroughs, resulting in large-scale production of synthetic fuels and chemical engineering feedstocks as replacements for petroleum and natural gas. Preliminary statistics indicate that by the year 2030, nearly 60 percent of the world coal output will be used to produce synthetic fuels.

2. Coal Transport

The mid- and long-term energy structure will still be based primarily on coal, the output of which will be 3 to 4 times the present level. The centers of coal production are primarily in Shanxi, western Mongolia, Shaanxi, Ningxia, and western Henan, while the coal-poor regions are in east China, the northeast, and south China, so that the need to ship coal from north to south and from west to east cannot be avoided.

According to 1984 statistics, the total output of raw coal was 780 million tons, while rail transport accounted for only 490 million tons, or 62 percent of the total. Raw coal transport accounted for 40 percent of total railroad haulage. Many mines already have backlogs of coal that they cannot ship. In order to prevent spontaneous combustion of the coal, they have had to adjust their output to transport capabilities. Over the middle and long term, coal output will reach 3 to 4 billion tons per year, and if the necessary steps are not taken to solve the coal transport problem, it will be difficult to achieve economic growth.

There are several ways of dealing with the problem.

First, the proportion of raw coal that is washed must be increased, and its water and ash content and the proportion of gangue must be decreased in order to decrease unproductive haulage. At present, less than 20 percent of coal is washed nationwide; almost none of the coal used for motive power is washed. Transporting high-quality coal would greatly decrease haulage and reduce transport costs.

Second, on-site or local processing and utilization of coal must be increased in order to decrease haulage. It is not worthwhile to transport brown coal and low-caloric-value fuels, which should be consumed locally; pithead power plants should be built and combined coal mining and power generating operations should be expanded. The advantages of the coal situation should be utilized by increasing coal conversion and processing in mining areas, gradually developing integrated chemical engineering use of coal, and expanding diversified coal industry operations.

Third, diversified transport methods should be expanded in order to increase coal transport. At present, railroad haulage represents the backbone of coal transport, accounting for about 54 percent of the total. Major efforts should be made to develop special through training so as to increase haulage capacities. In addition, thorough use should be made of water transport by expanding harbor construction and developing combined water-land transport. Pipeline transport and high-voltage electric transmission lines are additional methods of solving the coal transport problem. They too should be expanded where technical and economic conditions permit.

3. Pollution Caused by Coal

Direct coal combustion is a major source of atmospheric pollution. It produces acid rain and flyash and causes environmental pollution and ecological damage, and thus constitutes an extremely pernicious problem in the context of a large-scale expansion of coal use. Preliminary statistics indicate that the total amount of flyash discharged as a result of coal combustion is as high as 13 million tons per year, sulfur dioxide emissions total 10 million tons a year, and nitrogen oxide emissions reach 3.5 million tons a year; 96 percent of pollutant emissions from fuel combustion are produced by direct combustion of coal. The total content of particular matter in the atmosphere above northern cities is as high as 0.93 milligrams per cubic meter, several times the international standard. The sulfur dioxide content of the air reaches 0.12 milligrams per cubic meter. Sulfur dioxide pollution is even more serious in areas where high-sulfur coal is used: acid rain is already appearing.

Although China has large amounts of low-sulfur coal, the output of high-sulfur coal will tend to increase with deeper extraction. In north China and east China, for example, deeply buried coal seams contain high-sulfur coal, so that coal quality will decline. In the middle and long term, with large-scale increases in coal output, if strict measures are not taken to control environmental pollution, unthinkable consequences will result.

The United States has drafted a clean coal technology plan in order to decrease pollution by coal and increase the rate of its utilization; $6 billion will be invested between 1986 and 1992. Based on a comprehensive evaluation, the U.S. Department of Energy designated nine [as published] priority technologies, namely beneficiation, improved coal-burning units, stack gas purification, surface coal gasification, gasified-coal fuel cells, underground coal gasification, coal liquefication, and new direct iron-making technologies. These technical measures merit consideration in China.

We should now be taking the following steps. We should increase the percentage of coal that is washed; high-sulfur and high-ash coals formative power should also be washed in order to decrease pollution. We should increase power plant and stack gas purification and sulfur removal capabilities, and control flyash and gaseous pollutants. We should vigorously expand the supplying of coal gas and clean coals to city dwellers. We should develop advanced coal combustion and conversion (gasification and liquefication) technologies; and we should set strict pollution control standards and draft environmental management guidelines.

We must rely on scientific and technical advances to solve the above three problems. According to calculations by the Comprehensive Planning Office of the State Planning Commission, the technical level of the coal industry is the lowest of 17 industries, and its rate of technical progress is the slowest at 0.78 percent, compared with 1 to 5 percent in the other industries. Technical progress accounts for only 9.2 percent of the total increase in output value, while the figure ranges from 9.9 to 47 percent in the other industries.

If the coal industry is to accelerate technical progress and carry out modernization, it should start with the present. Before there is a serious coal supply problem, we must consider the energy crises that await us in mid- and long-term economic development. We should make use of new technologies, processes, and equipment and institute concentration, integrated mechanization, and automation of coal production. We should make major efforts to develop the use of processed coal, local coal conversion, and diversified coal industry enterprises, and to achieve high-efficiency utilization of coal resources, conservation of transport capacities, and decreased environmental pollution.

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BRIEFS

COAL OUTPUT UP 5.4 PERCENT--Beijing, April 5 (XINHUA)--China mined more than 205 million tons of coal in the first quarter of the year, or 5.4 percent over the same 1987 period. According to statistics just released from the Coal Ministry, this figure covers 22 percent of the 930-million-ton 1988 quota. The ministry also said, first quarter tunnelling footage was 178,973 meters, or 27.5 percent of this year's target. However, the ministry said, problems related to power shortage and transportation still exist, and mines in Shanxi Province and northeast China still have up to 18 million tons of coal waiting to be moved out. [Excerpts] [Beijing XINHUA in English 1110 GMT 5 Apr 88] 40100017/9365

INDUSTRY MODERNIZATION RECOMMENDATIONS--Beijing, 17 March (XINHUA)--China should tackle problems of deep mining, transport, and pollution to modernize its coal industry and meet increasing demands of coal, said an article in BEIJING SCIENCE AND TECHNOLOGY NEWS. At its present annual growth rate, China will need 1.4 billion tons of coal a year by the year 2000, 2.9 billion tons by 2030, and 4 billion tons by 2050. To meet the increasing demand, China has to rely more on deep mining, the paper said. Only 25 percent of China's coal mines are using mechanization, an effective means to save manpower in deep mines now widely used in developed countries, the paper said. And the use of computers in coal mining is now confined to laboratories in China. Many mines in the country figure their output not on their production capabilities but on transport facilities at their disposal. Many coal mines have had to stockpile large quantities of coal. The article suggested more coal be used by factories situated near the mine to reduce the amount which needs to be transported. Direct rail transport should be provided, especially for coal. Railways now handle 54 percent of the total coal transport. Coal should be sent by ship or via a combination of land and sea transport to lessen the burden on the railways. [Text] [Beijing XINHUA in English 0650 GMT 17 Mar 88] 40100017/9365

BRIEFS

NEW DAQING FIELDS FOUND--Harbin, 12 March (XINHUA)--Geologists have found five gas fields with verified reserves amounting to 20 billion cubic metres at spots round Daqing, China's largest oil field. The first was discovered in 1986, officials here said. Geologists hope to verify gas reserves of anywhere between 80 billion and 100 billion cubic metres in Daqing area by the end of this century. [Text] [Beijing XINHUA in English 1448 GMT 12 Mar 88] 04100018/9365

PIPELINE CONNECTS HENAN, HEBEI--Beijing, 14 March (XINHUA)--The longest natural gas pipeline in north China, constructed at a cost of 100 million yuan, was recently put into operation in the Central Plains Oil Field in China's Henan Province. The conduit, beginning in Puyang County in the Central Plains Oil Field and terminating at the Cangzhou Chemical Fertilizer Factory in Hebei Province, has a length of more than 400 km with five gas compression stations located at intervals along its length, its annual flow capacity is expected to hit 400 million cubic meters. The project has taken 4 years to complete. [Text] [Beijing XINHUA in English 1243 GMT 14 Mar 88] 40100018/9365

Nuclear Energy Seen as Answer to Nation's Power Problem

40130063 Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 24 Mar 88 p 2

[Article* by Guo Xingqu [6753 2502 3255]: "Key to Energy Problem--Nuclear Power"]

[Excerpts] 1. In this century, nuclear power will be only a supplementary energy source in China. The main objective [now] is to grasp the technology.

Nuclear energy has been under development in China for over 30 years. Due to various reasons, the construction of nuclear power plants was delayed for over a decade. In order to narrow the gap and to meet our needs, it is correct to directly import the large-scale pressurized-water reactor technology from other nations. However, our objective is to build our own nuclear industry to serve as a foundation for expansion in the next century. As it takes a certain process to grasp a technology, the scale of nuclear energy in China in this century is limited.

Di's article primarily explained why nuclear energy could not expand to a very large scale in China in the near future. There is essentially no direct connection with my opinion. Di's article projected that by 2000 the nuclear power plants in China will have a total capacity of 10 million to 12 million kW. In my article, however, it was estimated to be 6.7 million to 10 million kW, the 6.7 million figure being the essential minimum for China to grasp the technology and to build an industry in this century.

2. Nuclear energy is the answer to energy, environmental, and transportation problems in China.

Coal can be profitably mined only at a certain depth and thickness. The World Energy Conference estimated that only 6 percent of the coal reserve can be economically mined. Although the theoretical coal reserve in China is 4 billion tons and the known reserve is 840 billion tons, however, the amount that can be economically mined is limited. Hence, after coal consumption reaches 3 billion tons by 2020, it will be very difficult to continue to grow to meet the rising energy demand.

The air in Beijing was clean and clear 200 years ago. It was possible to see the travelers on Lugou Bridge 13 kilometers away from Guanganmen. However, pollution has become very serious lately. The average number of smog days per year was 45 in the 1950's, 70 in the 1960's, 100 in the 1970's, 150 in 1980, and 199 in 1981. The particulate concentration in the air in Beijing is 15 times higher than that in Tokyo and much higher than that in London. The environmental problem will get worse as the consumption of coal continues to rise.

Currently, 40 percent of the railroad freight capacity is used to transport coal. By early next century the coal mines in eastern China will be depleted and the energy industry will strategically move westward. Not only will the demand multiply but also the distance will increase by several fold. Therefore, it is impossible to relieve the tight transportation situation as long as coal is the primary source of energy.

Based on the present situation, petroleum production in China will not meet domestic needs by 2000. China will have to import oil. The water resources per capita are very limited in China. We should give priority to the development of hydroelectric power. However, after reaching approximately 10 percent of this total energy consumption by early next century, the relative share of hydroelectric power will decline as the total energy consumption continues to increase. The relative share of natural gas is also limited.

It is not difficult to conclude from the above discussion that only nuclear energy can fundamentally solve the energy, environmental, and transportation problems in China.

3. It is feasible to make nuclear energy the principle energy source in China by 2040.

Some experts believe that the uranium supply in China is only sufficient to operate 150 million kW for 30 years. However, the present pressurized-water reactor can only utilize 0.5 percent of the uranium. The fast neutron breeder reactor can utilize 70 percent of the uranium which makes it economical to mine low-grade uranium ores. The French breeder reactor uses an oxide nuclear fuel. Its multiplier time, i.e., the time needed for the fuel to double, is long. The multiplier time for a breeder reactor that uses a metallic nuclear fuel can be as short as 6 years. France spent over 20 years from an experimental breeder reactor, a demonstration breeder reactor to the full development of a commercial breeder reactor. However, this development process need not be repeated. South Korea plans to directly import the necessary technology to develop commercial breeder reactors.

If China completes an experimental breeder reactor in this century and begins to develop a breeder reactor that uses metallic fuel in the next century, based on the calculation made by the author, it may be feasible for China to use nuclear energy as the primary energy source in 2040.

India's uranium resource is comparable to China's. However, they estimate that 350 million kW of power may be generated by nuclear energy by the middle of the next century even with the lower performance carbide fuel breeder reactor.

As for my view about the energy outlook for China and the world, interested readers may refer to my book entitled "Nuclear Energy: An Important Post-20th Century Energy Source" (published by the Atomic Publishing Company, 1987). The computer program and results in this area were described in detail in my paper entitled "Projection of Energy and Nuclear Energy Demand in China in the 21st Century" (see June 1987 issue of HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING].

Footnote

*Since 1986, the author published a series of papers expressing the prospect of nuclear power in China based on my view and pointing out that nuclear energy may be the dominant energy resource by 2040. Di Yongping [5049 3057 1627] and Ji Hua [0679 5478] wrote an article entitled "Nuclear Energy Development in China" which was published in RENMIN RIBAO (OVERSEAS EDITION) on 10 February 1988. In that article, they disagreed with my view. This article is written to further the discussion.

Simulation Indicates Nuclear Power as Main Energy Source After 2040

40130061 Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 7 No 2, Jun 87 pp 158-163

[Article by Guo Xingqu [6753 2502 3255], Institute of Nuclear Power: "Forecast of China's Energy and Nuclear Power Requirements in the 21st Century"]

[Text] **Abstract.** Long-range computer modeling of China's energy requirements in the next century based on population and economic development scenarios indicates that by the year 2050, China's total energy consumption will reach 5.25-6.75 billion tons of standard coal a year, about 6 to 8 times the total 1986 level of consumption of commercial energy resources. Although fossil fuels will continue to be the principal energy source in the early part of the next century, by the 2020's annual fossil fuel consumption will fall rapidly after reaching a level of 1.655-2.044 billion tons of standard coal. This is because fossil fuel reserves that can be extracted economically are limited, a large transport capacity would be required, and fossil fuels would produce severe pollution with profound effects on global climate; they will therefore increasingly be diverted as feedstocks for the chemical industry. Use of renewable energy resources will increase, but the supply of these resources too is limited; thus, as energy consumption rises their share of the total will fall from 36 percent at the beginning of the next century to about 20 percent at mid-century. Nuclear power will expand rapidly at the beginning of the century, and by about the year 2040 it is likely to account for more than 50 percent of the total, thus becoming China's main energy source.

I. Introduction

Owing to its long construction time and long operating life of energy projects, major changes in the energy system will continue for more than 50 years. Long-range energy development forecasts are therefore needed. Until the 1970's, computation formulas based on earlier statistics were usually used to extrapolate short-term energy development trends. From the 1970's on, as the effect of political and social factors on energy resources became increasingly pronounced, the extrapolation usually failed. Some investigators began to construct possible future scenarios on the basis of past experience and current development trends, and to use computers to calculate the consequences of the scenarios in order to analyze their validity. Other investigators used probability to introduce uncertainty into mathematical models, thus creating probabilistic models that were different from decision-theory models.[1] Differences in modeling technique and in decision criteria resulted in different conclusions.[2]

The human brian is superior to computers in making distinctions and decisions, inference and association in ill-defined situations. As a result, while in earlier computation procedures the relevant numerical values and formulas were chosen ahead of time and all subsequent operations were done by computers, now computer calculations are increasingly combined with human analysis and decision-making in studying energy problems, with their extremely complex interaction between the numerous factors of this type. For example, the IIASA [International Institute of Applied Systems Analysis] energy model, which is based on economic development and population growth scenarios, contains four independent submodels: energy consumption, energy supplies and conversions, investment and expenses, and economic factors. The submodels are interconnected by means of human computations and decisions. This type of modeling was used to investigate the evolution of the world energy system up to the year 2030.[3,4]

As in the above models, the author combined human computations and decisions with computer calculations to perform year-by-year modeling of more than 80 variables related to China's energy consumption in the next century.

II. Design of the Model

Like the IIASA model, the model described here was based on scenarios, including human computations and decisions, computer calculations, and direct information flow and feedback. For simplicity, the model assumes only one population scenario: that the average fertility rate of females will be 1.5 until the year 2000, and thereafter will fall slightly below 1.5, gradually increasing again in the latter part of the 21st century. Based on circumstances in this country and abroad, and with consideration of future scientific and technical development and China's distinctive characteristics, the energy elasticity factor was assumed to be 0.62 in the year 2000, gradually decreasing thereafter to 0.5736 in the year 2060 and to 0.5446 in 2100. We calculated high and low energy scenarios, based on different assumptions regarding economic development. The nuclear power requirement was determined by subtracting fossil fuel and renewable energy reserves from total energy consumption. Because Chinese investigators have already made a thorough study of the national energy situation through the year 2000 and have reached a consensus on the subject, this model began at the year 2000. It was of course not intended for use in yearly plans for China's energy development in the next century, but for an investigation of the likely evolution of China's energy system during the next century.

III. Computation Results and Analysis

The above model was programmed in FORTRAN-77 and the calculations were made on a Cyber 825 computer; the main results are shown in Table 1.

Table 1. Main Results of Energy Projections for China in the 21st Century

Year		2000	2010	2020	2030	2040	2050	2075	2100
Population, 10^8		11.800	12.124	12.194	12.000	11.567	10.945	8.968	7.000
Per-capita output value, 10^4 U.S. dollars/year	H	0.800	1.532	2.793	4.631	7.054	10.067	20.196	34.051
	L	0.800	1.288	2.104	3.307	4.905	6.905	13.674	22.991
Per-capita energy consumption, tons std coal/yr	H	1.345	2.009	2.894	3.914	5.014	6.165	9.164	12.240
	L	1.318	1.768	2.380	3.116	3.930	4.793	7.073	9.432
Total energy consumption, 10^8 tons std coal/yr	H	15.869	24.361	35.283	46.962	57.996	67.473	82.168	85.680
	L	15.554	21.429	29.017	37.394	45.458	52.462	63.429	66.022
Renewable energy resources, 10^8 tons std coal/yr	H	5.739	7.869	9.728	11.002	12.030	12.886	14.459	15.323
	L	5.470	6.842	8.521	9.752	10.772	11.618	13.117	13.898
Hydropower	H	1.200	2.660	3.340	3.651	3.788	3.842	3.848	3.807
	L	0.959	2.008	2.697	3.144	3.428	3.602	3.766	3.746
Noncommercial energy sources	*	4.400	3.596	3.021	2.558	2.155	1.794	1.047	0.521
Other renewable energy resources	H	0.139	1.613	3.367	4.793	6.088	7.251	9.564	10.996
	L	0.111	1.238	2.803	4.050	5.190	6.222	8.304	9.630
Fossil fuel, 10^8 tons std coal/yr	H	9.900	14.776	19.604	19.604	14.776	9.900	3.887	1.932
	L	9.900	13.860	16.553	14.260	9.900	6.558	2.694	1.291
Nuclear power, 10^8 tons std coal/yr	H	0.230	1.715	5.951	16.356	31.189	44.687	63.840	68.425
	L	0.184	0.727	3.943	13.382	24.786	34.286	47.618	50.733

*Only one scenario was assumed for noncommercial energy sources.
H: High
L: Low

It is evident from the table that even if China continues its birth control policy, the inertial high rate of increase in population over the course of 3 decades will result in continuing population growth at the beginning of the next century; the current level will be restored only at mid-century. China's per-capita land area, mineral resources and water resources are only between a quarter and half the world per-capita figures, and its population is unlikely to decrease to an ideal level by the end of the 21st century.

In the year 2050, China's per-capita output and per-capita energy consumption will still be low, equal to only about half the current levels in the most advanced countries. But because of the large population, China's total output and total energy consumption will propel it to the forefront worldwide. The model indicates that China's per-capita output and per-capita energy consumption will increase continuously from the middle of the next century on, but total energy consumption will tend to stabilize. China can move toward advanced levels in per-capita output and per-capita energy consumption by achieving economic development and further decreases in population; these factors should be planned for 100 or more years in advance.

We divide renewable energy resources into hydropower, noncommercial energy sources, and other renewable resources. The hydropower resources that China can develop economically amount to about 1.9 trillion kWh per year. At the current power generation efficiency of fossil-fired power plants, this is equivalent to 700 million tons of standard coal in nonrenewable energy resources per year. As a result of silting of reservoirs and future increases in [fossil-fired] power generation efficiency, the quantity of nonrenewable resources that hydropower will be able to replace will fall below this figure. We should accord high priority to developing hydropower, but our hydropower resources are limited, and as total energy consumption increases, the percentage of nonrenewable resources that it can replace will fall from 9.55 to 10.94 percent at the beginning of the next century to a stable level of about 6 percent at mid-century. Noncommercial energy sources are currently the primary energy resources of the countryside, but they will gradually decrease in the next century as modernization proceeds.

China's wind power, geothermal power, tidal power, and wave power resources that can be developed economically are extremely limited. Taking account of conversion factors, equipment utilization rates and auxiliary measures, the construction of durable solar power plants[4-7] with an output equivalent to 100 million tons of standard coal per year will require from several hundred million to over a billion tons of reinforced concrete and will take up several tens of thousands of square kilometers of land, at a land procurement cost of several hundred billion yuan. If the plants are built in desert areas, there will be a saving on land acquisition costs, but the cost of the improvements that will be needed in order to allow construction in the desert will be even higher. If solar power plants were built in geostationary orbit, the weight per unit output of power would be too great; in addition the rapid increase in communications satellites and the like has already made geostationary orbits crowded, so that it will be impossible to build stations in large numbers. To summarize, solar power has a low energy flux density, its output varies with the time of day, the weather, and the season, and large amounts of materials and large areas are required; it is thus unlikely to become a large-scale industrial energy source. But as a source of energy for households and other special uses, solar power has great promise. It is a supplementary energy source for the future, but there are limits on its rate of expansion. At the beginning of the next century the other renewable sources of energy will be primarily biomass plants converted from noncommercial energy sources, and it will be only at mid-century that solar energy will begin to play an important role, alongside hydropower, among renewable energy resource. Nonetheless, renewable resources will consistently account for about 20 percent of total energy output after the middle of the century.

Because of delays in the development of nuclear power and the rapid increase in energy consumption, China's main source of power will continue to be fossil fuels in the early part of the next century. But owing to environmental constraints and increasing conversion of fossil fuels into chemical feedstocks, after reaching 1.655-2.044 billion tons of standard coal in the 2020's, the output of energy from fossil fuel will begin to decline rapidly. Even so, between 2000 and 2050 the cumulative amount of energy produced from fossil fuel will be as high as 6.416-8.033 billion tons of standard coal, while by 2100 it will reach 7.939-10.298 billion tons of standard coal. If we add to these figures the consumption of chemical-industry feedstocks during this period, the result will approach or even exceed China's economically recoverable fossil fuel resources. Even though by the next century the sulfur and ash content of China's coals are likely to decrease greatly, between the year 2000 and 2050 China's total cumulative sulfur dioxide output will still be as high as 1.124-1.304 million tons, and the total production of ash will reach 8.569-10.259 billion tons. This is equivalent to 117.08-135.83 tons of carbon dioxide and 892.60-1,060.64 tons of coal ash for each square kilometer of land in the country. Only by greatly increasing environmental investments can China tolerate such severe pollution. During this period, the total output of carbon dioxide will be between 186.56 and 233.55 billion tons, which may have serious effects on world climate. As a result, the annual consumption rate of fossil fuels for energy production given by the model represents the greatest choice in a situation that gives no good alternative.

Under these circumstances, rapid expansion of China's energy consumption can only be provided by nuclear power. At the beginning of the next century, China's total energy consumption will increase by an average of about 3.26 to 5.48 percent per year, while the rate of expansion of nuclear power will average 14.72 to 22.25 percent per year. By the year 2040, the rates of increase of total energy consumption and nuclear power will have fallen respectively to 1.72-1.83 percent and 4.57-5.04 percent a year. Thus, by about the year 2038 nuclear power will account for more than 50 percent of nonrenewable energy resources; its share will ultimately stabilize at about 80 percent. At the same time, hydrogen power will be developing rapidly as a secondary energy source; after the middle of the next century it will gradually replace fossil fuels in their final stronghold, the transportation industry.

The increased use of nuclear power and the decreased use of fossil fuels will make increasing amounts of raw materials available to the chemical industry and the future biological industry, while the transport industry will be relieved of the burden of energy transport, which will contribute to the further prosperity of the economy. Decreased pollution from coal will make the land even more attractive.

If in the year 2050 China uses 50 percent of its nonrenewable energy resources to generate energy, then the per-capita output of electrical energy will be 9,760 to 12,550 kWh, about half Norway's current per-capita output and close to the current U.S. level.

As the above discussion indicates, the first half of the next century and in particular its first 3 decades will be a difficult period in the development of China's energy industry. Economic development and our huge population will result in a rapid increase in total energy consumption. China's energy industry is facing a series of difficulties that stand in the way of rapid expansion of fossil fuel supplies and it must make the changeover from fossil fuel to nuclear power. After the middle of the century, the changeover to nuclear power will be complete and a large fraction of the increase in both per-capita output value and per-capita energy consumption will result from a decrease in population. At that time China's economy will have entered the stage of highly coordinated development.[8-10]

IV. Conclusions

A. Population and energy are the two most important and most difficult problems in achieving China's strategic goals in economic development. Other problems either are of less importance or less pressing, or arise from the above two problems. We should keep our population below 1.2 billion in the present century and bring it down to current levels in the middle of the next century. If we cannot effectively control population, China's economic development and its energy industry will be increasingly controlled by other factors.

B. The pace of nuclear power development must be stepped up. The key to expanding it appropriately in the present century is establishing a nuclear power industry based primarily on pressurized-water reactors and setting up experimental breeder reactors and developing demonstration breeder reactors in order to set the stage for rapid development of nuclear power at the beginning of the next century. In addition, we must proceed quickly with research and applications on coal liquefication and gasification and minimize pollution from coal. A high priority must also be given to biomass power.

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